COMPUTER GAME MOTIVATING REHABILITATION WITH OBJECTIVE MEASURES OF IMPROVEMENT IN MOTOR FUNCTION

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Abstract- **We constructed and interfaced an actuator/sensor to a game of pong TO PRODUCE HIGHLY MOTIVATING REHABILITATION FOR PERSONS WITH ARMS PARTIALLY PARALYZED FROM A STROKE. In addition to moving the pong paddle the subject's motions can be recorded to provide objective measures of improvement in movement range, accuracy, and dynamics. A preliminary patient study revealed a high level of patient interest and satisfaction. Even patients who had no familiarity with computers (the prototype is connected to a computer) and approached the system with trepidation, were soon interested and involved. One hemiparetic aged man initially refused to use the system because he did not think his arm could perform the task, but after a short session in which he performed well, he asked if he could take it home. Patients get very involved and show a high level of concentration.**

Keywords- **Computer game rehabilitation, hemiplegia, motivating, objective measures**

I. INTRODUCTION

Rehabilitation procedures that engage emotions and the mind apparently activate parts of the brain that may influence the recovery process. We have developed a prototype of a motivating, functional rehabilitation program for hemiparetic upper extremities. It is based on a system developed 25 years ago [1]; modern technology offers the potential for practical, cost effective systems to be used in institutions and at home, with internet connections to the rehabilitation center.

II. METHODOLOGY

A Herring track-type sliding lever is controlled by the patient with the hemiparetic arm. Instead of exercise, the patient is engaged in a game (e.g., ping-pong) and with practice, instead of concentrating on the arm movements, he/she is concentrating on the game, with the arm movements becoming sub-conscious. Patients, even those who initially consider that they can not accomplish the task, show interest and improvement.

Fig. 1. Pong game described by Cogan et al. [1].

Figure 1 shows the original pong game developed in 1977 [1]. The current version of the actuator/sensor sliding lever is shown in figure 2. The lever is attached to a "trolley car" which rolls on ball bearing wheels inside a wooden box. The lever can be made to have variable load and so be adjusted to the patients' level of strength and ability. A linear array of 64 retroreflective sensors detect the position of the trolley. Only one of the 64 sensors is active at any lever position. This information is encoded as a binary number and transmitted to control the pong paddle via the parallel port of any IBM compatible computer. A different interface will be developed which will allow use with MACintosh computers. In addition to controlling the game, the system can record the movements of the patients' hemiparetic limb and these objective data are intended to be used to track the patients' rehabilitation progress. Although it was labor intensive to manually construct the array of inexpensive retroreflective sensors for this prototype, a printed circuit board could be used to position and wire the sensors and thus reduce the labor required to construct a device like this.

This specific project was based on prior work [1, 2, 3] and redeveloped via a collaboration between rehabilitation

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Abstract

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specialists and experienced instrumentation engineers. The system was built by engineering students at the Instituto de Tecnologia de Monterrey, campus Morelos, Mexico as a senior design project during a supervised two semester course. Some of the design goals for this system were:

1. Low cost, flexible, and easy to install. Typically physical therapists would introduce patients to the system and train them on how to work it and how to use it as a data collection device.
2. Compatible with older hardware like MS-DOS based computers.
3. Use of only free software so that the system could be distributed without the need to pay royalties.

The sensor system was chosen to be low cost and easy to build. Given the constraint of DOS compatibility, the parallel port approach seemed reasonable. Since the completion of this project we have considered and will implement more efficient sensor designs.

Fig. 2. Newly developed and improved actuator/sensor. The linear array of retroreflective position sensors is located inside the wooden "trolley box". The box connects directly to the parallel printer port of even DOS based computers. The subject moves a U-shaped lever to move the paddle and play pong against the computer or against another person.

The broad goals of this theory-based and objective results-driven approach to rehabilitation are to develop a modern, inexpensive game-based training device for persons with hemiparetic upper extremities. We expect to extend this model to other disabilities such as gait training and develop internet capabilities to allow patients to use the devices in cooperation with rehabilitation personnel, and to play therapeutic games from one home to another

III. Results of preliminary study

Only exploratory studies have been undertaken to date. Persons with long-standing upper extremity hemiparesis (reduced function) due to a stroke were pleased with the device, and even those who were initially were reluctant to try it found that they quickly developed better arm control All wished to continue using the device. **One hemiparetic aged man initially refused to use the system because he did not think his arm could perform the task, but after a short session in which he performed well, he asked if he could take it home. Patients get very involved and show a high level of concentration.**

The initial studies revealed several deficiencies that will be corrected before formal studies are initiated. These include: the need for a better arm rest; the need to have a variable height adjustment; the need for several alternate means of interfacing the paretic hand with the device for those who are unable to grasp it (for the 1977 study, there were several alternate patient-to-lever interfaces). We plan to develop improved control over ball speed and paddle size and will develop other game software, besides the pong game, for the device. The interfaces tested so far are one-dimensional. We have begun to plan two and three-dimensional patient interfaces.

It is yet to be determined whether objective measures of patient performance will improve the overall rehabilitation process. However, this will be the first time objective outcomes will be available to guide therapy.

IV. Discussion

Modern rehabilitation methodology is long overdue. There has been little published about the difficulties patients have retaining skills learned in hospital rehabilitation programs. Learned skills are rarely carried over from one hospital session to the next and not surprisingly these skills do not transfer well from the clinic to the home environment [4, 5]. Rehabilitation that engages the patient in motivating, function-based activities has greater carry over. This preliminary report describes a highly motivating rehabilitation computer game-based device.

V. Conclusion

Disability is extremely common and costly for the individual and for society. The capacity for early and late brain reorganization is no longer in doubt [3]. Most patients have the ability to recover lost function but traditional nontheory-based methods of rehabilitation have not realized this potential. A motivating rehabilitation computer game has been developed to maximize recovery of function of persons with partially paralyzed arms.

Fig. 3. A student is shown using the pong game exercise device that is connected via a single cable to the parallel port of the black laptop computer in front of the separate computer monitor

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